BULLETIN 264 JULY, 1938

AGRICULTURAL EXPERIMENT STATION
OF THE RHODE ISLAND STATE COLLEGE
Kingston, Rhode Island, U. S. A.

Lawn Grasses and Their Management

By H. F. A. North, T. E. Odland, and J. A. DeFrance

IMPERIAL MYCOLOGICAL
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A FINE LAWN SEEDED WITH RHODE ISLAND COLONIAL BENT

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ABSTRACT

This bulletin is designed to furnish information for those interested in the growing and maintenance of lawn turf. It is based on experimental work begun shortly after the experiment station was established at Kingston and continued since that time.

The experiments have included tests with different lawn grasses, various kinds of fertilizers, liming, and weed control.

Soils were changed gradually in their chemical reaction by different fertilizers applied. An acid reacting fertilizer gradually increased the soil acidity on one set of plats over a 30-year period; a basic fertilizer gradually made another set of plats decidedly alkaline in reaction.

In the acid plats, weeds were controlled effectively by the fertilizer treatments but the turf was not as vigorous as on the less acid plats. Too high acidity resulted in a "sod-bound" condition in the turf.

The alkaline plats became badly infested with weeds, although certain grasses made a very vigorous growth. Plats neither too acid nor too alkaline, pH 5 to 6, produced the most satisfactory turf when all factors were considered.

Sulfate of ammonia, when mixed with an equal weight of limestone to prevent the soil from becoming more acid, proved superior to nitrate of soda in maintaining desirable turf.

Sulfate of ammonia, used as the source of nitrogen in the fertilizer, reduced the amount of white clover in the turf.

On Kentucky bluegrass, manure alone or a complete fertilizer was more effective in maintaining a good quality of turf than either nitrate of soda or sulfate of ammonia used alone.

In a mixture of Rhode Island bent and Kentucky bluegrass, the tendency was for the Rhode Island bent to become the predominant grass in the turf.

Applying compost on old lawns as a topdressing resulted in improving their average quality.

Lead arsenate proved very effective in controlling crabgrass and chickweed in turf. Sodium arsenite in the concentration used was effective for chickweed but not for crabgrass.

Lead arsenate was also effective in controlling earthworms and webworms in turf.

A fertilizer high in nitrogen, such as a 10-6-4, 8-6-6, or 8-6-4, is recommended for general use on lawns.

Suggested mixtures and rates of seeding are given for different types of lawns and for various soil conditions.

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BULLETIN 264 JULY, 1938

Lawn Grasses and Their Management[1]

By H. F. A. North, T. E. Odland, and J. A. DeFrance

Experiments with the growing and management of lawns and lawn grasses have been made over a period of forty-six years at the Rhode Island Agricultural Experiment Station. It is the purpose of this bulletin to report some of the more recent results obtained and to offer suggestions on lawn care and management based on these results.

The beauty of the grounds around a home is usually due fundamentally to the presence of good grass. It is the foreground of the home and the setting for plantings and other garden features. A beautiful green lawn with trees and shrubs properly located contributes greatly to the value of the home and to the enjoyment of the family.

There has been a gradual improvement in the quality of lawns in recent years. The putting green of the earlier golf course probably was of poorer quality than is the average lawn of today in Rhode Island. The decided change from the natural to the artificial environment for growth is one of the primary reasons for the increasing number of problems in the culture of lawns and greens.

DESCRIPTION OF LAWN EXPERIMENTS

Rhode Island has the distinction of being the first state to initiate lawn experiments through its agricultural experiment station. Experiments were begun in 1890 at the time Olcott (*11*)[2] had published results of his grass gardening. In 1905, a more comprehensive set of lawn plats was laid out and planted by Card (*1*) on the Agronomy Farm west of the College. It is interesting to note that the land had been well cultivated in advance and that the plantings were made in August. Good stands, relatively free from weeds, were obtained by planting at this time of year.

These plats have been used to determine the effect of acid, neutral, and basic reacting fertilizers on grasses, weeds, and soil; the amounts of important plant nutrients needed; the preference of grasses for different forms of nitrogen; and the behavior of different grasses individually and in mixtures.

Earlier results from this set of plats have been published by Card (*1, 2*) in 1906 and 1907; by Hartwell and Damon (*6*) in 1917; and by Garner and Damon (*4*) in 1929. At the time of the later publications, a reorganization was made in the treatments, such that the history of some plats has

[1]Contribution No. 515 of the station.
[2]Reference is made by number (*italics*) to Literature Cited, p. 36.

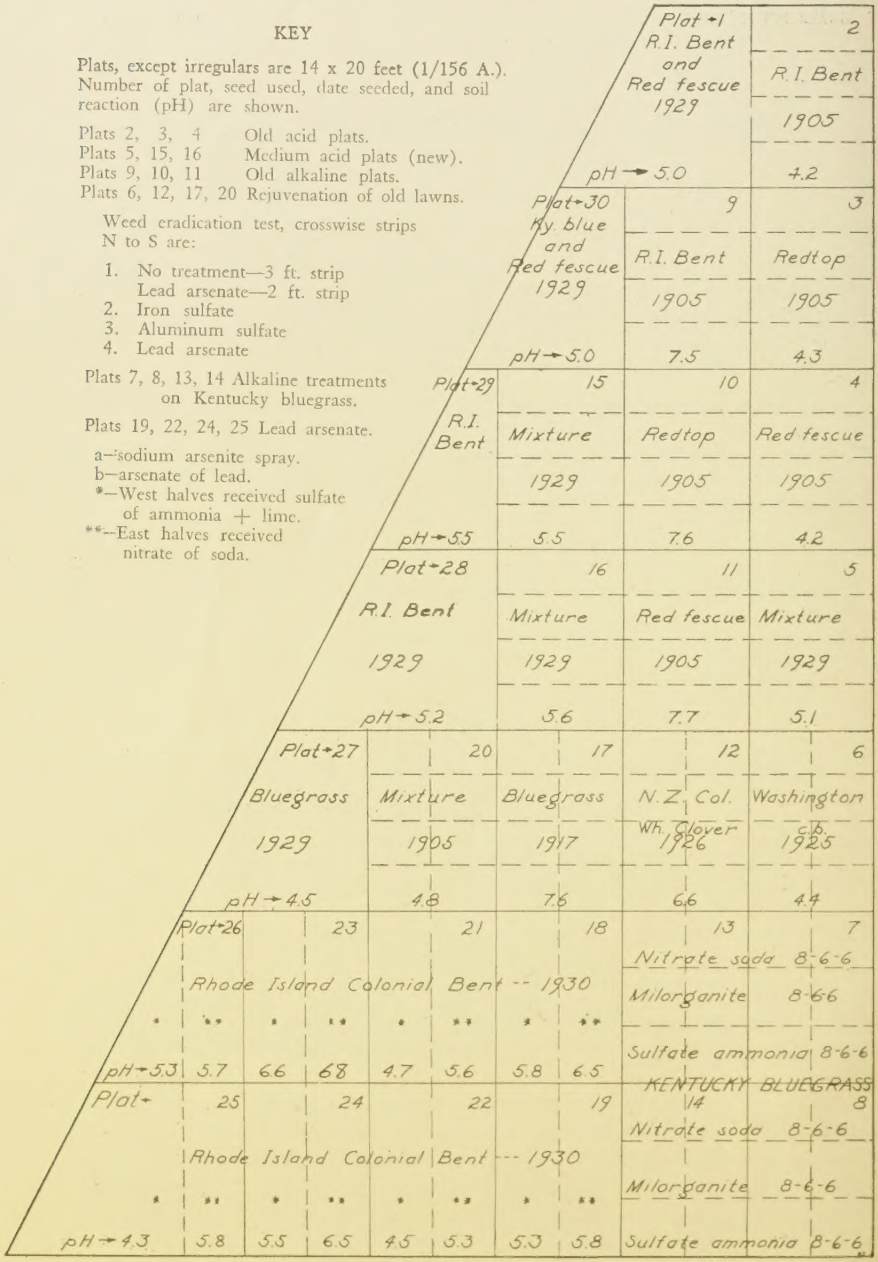

FIGURE 1. Old Lawn Plats—1936. Test of Different Grasses and Fertilizers for Lawns.

become rather complex. All of the plats, however, have been growing turf during the 30 years and seven have not been replanted during this time. On twenty-three plats the grasses and fertilizers have been changed from time to time and the plats vary widely in reaction and fertility. Twenty of the old plats were dug up, cultivated, and replanted late in 1929. Several of these were replanted in the early spring of 1930. A number of the plats have been subdivided for various purposes. Figure 1 shows the blocks devoted to the several experiments and the subdivision of the various plats.

Another set of lawn plats is located in the center of an athletic field on the campus and includes plantings of eleven grasses singly and a number in mixtures. This experiment was begun in order to determine the grasses and mixtures which wear the best under play in the autumn. A number of new lawns and athletic fields have been under observation and have yielded much valuable information. At the same time experiments have been conducted as follows: grass species and forms under close clipping, fertilizer ratios on fine turf, seed production of bent grasses, and the breeding of bent grasses.

METHODS OF TREATMENT

The lawn plats are rolled in early spring. Fertilizers and rates of application for the old lawn plats are shown in Table 1. It will be noticed that the nitrogen (N), phosphoric acid P_2O_5, and potash K_2O are expressed in pounds per 1000 square feet.

Mowing at a height of ¾ inch has been as frequent as twice a week, the clippings having been left on the ground except when weight measurements were taken. No weeds have been removed during the period 1931-1935, although some of the new plats were weeded in 1930. Water has been applied only during extended drouth or for the purpose of dissolving concentrated mineral fertilizers applied during late spring to early autumn. Since 1931, the plats have been rated as to the quality of the turf. This has been done by rating individual factors such as vigor, color, texture, density, and uniformity and taking the average. The scale was from 0 to 5 and ratings usually were made in April, June, August, and October. Color was rated each month from March to December. The factors are defined below. A rating of 1 is poor and 5 is excellent.

Vigor (0-5)—Rapidity of growth. This is particularly desirable in a new planting and during recovery from injury. In general, the weight of clippings also measured "vigor."

Color (0-5)—Brilliancy of green. Generally a yellow-green is more brilliant than a gray or very dark green. Brown leaves are discriminated against severely.

Texture (0-5)—Fineness of the leaf blades. Weeds and clover lower this rating.

Density (0-5)—Amount of crowding together of the green leaves. This assumes that the more compactly the leaves are arranged the better the sward.

TABLE 1. *Applications of fertilizer nutrients (N, P_2O_5, and K_2O) and limestone in pounds per 1000 sq. ft. to lawn plats during the period from 1929 to 1935.*

Plats	Nutrients supplied in the fertilizers							Limestone (ground)	Remarks (Amounts per 1000 sq. ft.)
	Nitrogen (N)			Phosphorus (P_2O_5)		Potash (K_2O)			
	Sul. of Ammonia	Nit. of Soda	Organic	Super-phosphate	Basic slag	Muriate	Wood ashes		
2, 3, 4	2.30			1.70		1.70			Compost 1/3 yd. 1929.
9, 10, 11		2.30		1.70		1.70		92[a]	Compost 1/3 yd. 1929.
5, 15, 16	1.15	1.15		1.70		1.70			Plat 5 limed at 92 lbs.[a] Nitrogen from nit. of soda 1929-1930.
6, 12, 20	1.15		Compost 1 yd.	1.38		1.15			Plats 6 and 20 received nitrate of soda in 1929.
17		1.15	Compost 1 yd.		1.38		1.15		Period 1929-1931. Muriate in 1932.
17	1.15		Compost 1 yd.		1.38	1.15			Period 1933-1935.
7	2.30							184	No fertilizer 1929-1930. In 1934 same fertilizer as plat 8.
8		2.30		1.70		1.70			
13			2.30[b]						
14		2.30							In 1934 same fertilizer as plat 8.
18, 19, 21, 22 West halves	4.14			1.70		1.70		c	Plats 21, 22, 25, 26, fertilized like 2, 3, 4, in 1930.
23, 24, 25, 26 East halves		4.14		1.70		1.70		d	Plats 18, 19, 23, 24, fertilized like 9, 10, 11 in 1930.
27, 28, 29, 30, 1	4.14			1.70		1.70		c	Same fertilizer as 2, 3, 4 in 1930.

a—Applied in 1929.
b—Manure 460 lbs. or 10 T per acre.
c—A weight of limestone equal to the sulphate of ammonia applied 1931-1935.
d—Plat 24 received 92 lbs. limestone in 1930 and again in 1931.

Uniformity (0-5)—The similarity of the appearance from place to place over the plat. Weeds, disease, or vacant patches reduce this rating.

The ratings include injury from disease and other causes, and the amount of weeds and clover. Estimates have been made also of the following individual points: vacant space, area of weeds, area of clover, area of disease, and number of worm casts. Clippings, as an average of individual mowings in April, June, August, and October, were calculated to pounds per 1000 square feet per season of 170 days.

Table 2 gives the numbers of the plats on which the different grasses and mixtures were planted, the year of planting, the treatment they received, and the average quality, the per cent rating combining all factors and based on the poorest plats as zero. The results will be discussed when each of the quality factors is considered.

EFFECT OF FERTILIZER AND LIME ON THE SOIL

Earlier lawn bulletins published by the Agricultural Experiment Station have shown that soils are changed gradually in their chemical reaction by the action of commercial fertilizers. Lime tends to make the soil more alkaline while some of the common nitrogen carriers tend to make the soil more acid. Farm manures tend to leave the reaction unchanged.

The various manure, fertilizer, and lime treatments used on these plats may be found by referring to Table 1. The effect of these treatments on the soil reaction may be seen by reference to Table 13.

The continuous use of sulfate of ammonia as the nitrogen carrier (plats 2, 3, 4), without the addition of any lime, has produced a very acid reaction in the soil. Where nitrate of soda has been used, the soil reaction has either remained at about the same level or the acidity has decreased.

The slowing down of the decay processes as the soil became acid, resulted in the accumulation of a felty mass of dead grass roots. This forms a very dense fibrous layer at the surface and becomes progressively less dense downward. The application of lime at the rate of 25 to 50 pounds per 1000 square feet changes the reaction and accelerates decay processes at the surface. This materially improves the absorption of rain and irrigation water.

If the lawn is composed of mixed grasses, the soil reaction should be adjusted to approximately pH 6.0 by the application of lime. An application of lime sufficient to overcome the increase in acidity caused by the fertilizer should suffice for the lawn of velvet or colonial bent or of fescue. The amount will approximate a pound of limestone for each pound of sulfate of ammonia. Changing the soil reaction by applications of lime on the surface should be done gradually as the lime moves into the soil slowly and may accumulate at the surface.

For practical liming recommendations the amounts of lime per 1000 square feet shown in Table 3, will be found satisfactory for changing the

reaction of soils 1.0 pH unit when the organic content is average or medium. For soils low in organic matter, these amounts may be reduced one-fourth and for soils high in organic matter (peats and mucks), they should be doubled.

TABLE 2. *The average estimated quality of the lawn turf plats during the seasons* 1931 *to* 1935.

Plat	Year of planting	Dominant Grasses	Treatment	Average Quality	
				Per cent	Per cent better than poorest
27	1929	R. I. Colonial, Velvet bent	Extra ammonia nitrogen + lime	83	48
29	1929	R. I. Colonial, (pure)	Extra ammonia nitrogen + lime	81	45
18W	1930	R. I. Colonial, (pure)	Extra ammonia nitrogen + lime	80	43
21W	1930	R. I. Colonial, (pure)	Extra ammonia nitrogen + lime	80	43
26W	1930	R. I. Colonial, (pure)	Extra ammonia nitrogen + lime	80	43
23W	1930	R. I. Colonial, (pure)	Extra ammonia nitrogen + lime	79	41
12W	1926	New Zealand Colonial, (pure)	Low ammonia nitrogen, Compost 4 years	79	41
23E	1930	R. I. Colonial, (pure)	Extra nitrate nitrogen	78	39
22W	1930	R. I. Colonial, (pure)	Extra ammonia nitrogen + lime	77	37
30	1929	R. I. Colonial, Ky. bluegrass	Extra ammonia nitrogen + lime	77	37
28	1929	R. I. Colonial, (pure)	Extra ammonia nitrogen + lime	77	37
12E	1926	New Zealand Colonial, (pure)	Low ammonia nitrogen, Compost 3 years	77	37
16	1930	R. I. Colonial, Ky. bluegrass	Ammonia and nitrate nitrogen	76	36
18E	1930	R. I. Colonial, (pure)	Extra ammonia nitrogen + lime	76	36
19W	1930	R. I. Colonial, (pure)	Extra ammonia nitrogen + lime	76	36
1	1929	R. I. Colonial, Sheep fescue	Extra ammonia nitrogen + lime	75	34
20W	1905	R. I. Colonial, Red and Hair fescue	Low ammonia nitrogen, Compost 4 years	75	34
11	1905	Red fescue	Nitrate nitrogen	75	34
5	1930	R. I. Colonial, Ky. bluegrass	Ammonia and nitrate nitrogen	74	32
15	1930	R. I. Colonial, Ky. bluegrass	Ammonia and nitrate nitrogen	73	30
25W	1930	R. I. Colonial, (pure)	Extra ammonia nitrogen + lime	71	27
21E	1930	R. I. Colonial, (pure)	Extra nitrate nitrogen	71	27
20E	1905	R. I. Colonial, Red and Hair fescue	Low nitrate nitrogen, Compost 3 years	71	27
4	1905	Red fescue	Ammonia nitrogen	70	25
19E	1930	R. I. Colonial, (pure)	Extra nitrate nitrogen	70	25
17W	1917	Ky. bluegrass, Colonial bent	Low nitrate nitrogen, Compost 4 years	69	23
17E	1917	Ky. bluegrass, Colonial bent	Low nitrate nitrogen, Compost 3 years	69	23
22E	1930	R. I. Colonial, (pure)	Extra nitrate nitrogen	68	21
24E	1930	R. I. Colonial, (pure)	Extra nitrate nitrogen	68	21
6W	1925	Washington Creeping Bent	Low ammonia nitrogen, Compost 4 years	67	20
10	1905	Fescue, bluegrass bents	Nitrate nitrogen	66	18
13S	1929	Ky. bluegrass, white clover	Manure nitrogen, Clipped ¾″	66	18
25E	1930	R. I. Colonial bent	Extra nitrate nitrogen	65	16
13N	1929	Ky. bluegrass, white clover	Manure nitrogen, Clipped 1¼″	65	16
3	1905	Fescue, bent	Nitrate nitrogen	65	16
6E	1925	Washington Creeping Bent	Low ammonia nitrogen, Compost 3 years	64	14
2	1905	R. I. Colonial, red fescue	Ammonia nitrogen	62	11
9	1905	Ky. bluegrass, bents	Nitrate nitrogen	61	9
14S	1929	Ky. bluegrass, bents	Nitrate nitrogen (only) Clipped ¾″	58	4
14N	1929	Ky. bluegrass, bents	Nitrate nitrogen (only) Clipped 1¼″	58	4
8N	1929	Ky. bluegrass, bents	Nitrate nitrogen, Clipped 1¼″	57	2
8S	1929	Ky. bluegrass, bents	Nitrate nitrogen, Clipped ¾″	57	2
7N	1929	Ky. bluegrass, bents, clover	Ammonia nitrogen, (only) Clipped 1¼″	56	0
7S	1929	Ky. bluegrass, bents, clover	Ammonia nitrogen (only) Clipped ¾″	56	0
		Average		70.5	

TABLE 3. *Amounts of lime required to change pH values one unit for practical liming recommendations.*

Soil class	Pounds of lime per 1000 square feet		
	Burnt lime*	Hydrated lime	Ground limestone
Light sandy soils	20	25	35
Sandy loams	25	35	45
Loams	40	50	65
Silt or clay loams	45	60	80

*Burnt lime will be injurious to grasses during the season of growth and neither burnt nor hydrated limes are as easily spread as limestone.

EFFECTS OF FERTILIZER AND LIME ON LAWN TURF

These turf experiments afford an opportunity to note the effect of various fertilizer combinations on the growth of different grasses and mixtures of grasses. The comparisons include various nitrogen sources, different amounts of phosphoric acid and potash; also, the effects of liming on different plats.

EFFECT OF NITROGENOUS FERTILIZER

Sulfate of ammonia vs. nitrate of soda

The lawn plats have served to show the effects of these nitrogen fertilizers over a period of 32 years. The application of sulfate of ammonia on plats 2, 3, and 4 and of nitrate of soda on plats 9, 10, and 11 have furnished equal amounts of nitrogen as shown in Table 1. To the casual observer, the acid, mildly acid, and basic plats differ mainly in the absence of weeds on plats 2, 3, and 4 as compared with 5, 15, and 16, also 9, 10, and 11. Reference to Table 4 will show differences in the quality of the turf nearly as striking. Plats 2, 3, and 4 excel 9, 10, and 11 in texture, uniformity, and freedom from weeds. Plats 5, 15, and 16 are superior in vigor and color. The high acidity plats show a pH of approximately 4.2 to 4.3, the basic, 7.5 to 7.6; and the mildly acid 5.2 to 6.1 (Tables 4 and 13).

A downward trend in quality is indicated by the annual ratings of the basic plats while the highly acid plats have remained practically the same. In average quality the basic and highly acid plats are nearly equal. The mildly acid reaction is shown to be more desirable by these ratings. Plats 5, 15, and 16 planted in 1930 and receiving an equal amount of nitrogen, half in ammonium sulfate and half in nitrate of soda, are approximately intermediate in factors of quality, weeds, and clover.

Table 5 shows the early greenness of plats 9, 10, and 11 as compared with plats 2, 3 and 4, and with 5, 15, and 16. The same general trend is shown in fall and winter. Plats 3 and 10, 4 and 11, are higher in color than 2 and 9, due to the larger amounts of fescue they contain. Discoloration of the chickweed in plats 9, 10, and 11 may account in part for the loss of color during warm weather. Plats 4 and 11 have remained almost pure red fescue during the thirty years of this test. The fescue grows well in cool and even cold weather.

TABLE 4 *The quality of lawn plats resulting from different fertilizers and soil reactions during the period from* 1931 *to* 1935.

Plat	Average ratings in factors of quality in per cent, 1931-1935					Average annual ratings in all factors of quality in per cent						Weeds Per cent	Clover Per cent
	Vigor	Color	Texture	Density	Uniformity*	1931	1932	1933	1934	1935	Average		
						Highly acid plats planted in 1905 (pH 4.2 to 4.3)							
2	40	52	82	67	69	66	70	55	58	62	62	3.3	0.1
3	44	58	86	69	71	68	70	62	61	64	65	2.9	0.1
4	43	60	87	71	82	71	71	72	69	68	70	2.1	0.2
Average	42	57	85	69	81	68	70	63	63	65	66	2.8	0.1
						Basic plats planted in 1905 (pH 7.5 to 7.6)							
9	67	65	53	70	39	76	64	56	56	52	61	30.5	9.4
10	72	67	62	74	46	78	65	66	61	59	66	28.7	12.0
11	72	75	76	83	70	82	74	80	75	64	75	10.0	10.0
Average	70	69	64	76	52	79	68	67	64	58	67	23.1	10.5
						Mildly acid plats planted in 1930 (pH 5.2 to 6.1)							
5	69	72	72	83	75	78	69	82	76	66	74	6.8	4.0
15	68	71	71	80	80	74	68	83	73	69	73	6.7	6.3
16	72	72	74	84	82	75	69	84	81	71	76	6.7	5.3
Average	70	72	72	82	79	76	69	83	77	69	74	6.7	5.2

*Period from 1933 to 1935.

TABLE 5. *Effect of soil reaction and fertilizer treatments on the seasonal change in color of the turf during the period* 1931 *to* 1934.

Plat	Average color ratings in per cent, 1931-1934								
	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
					Highly acid plats planted in 1905					
2	1	17	62	67	65	62	65	52	20	10
3	1	22	70	62	65	70	65	57	30	15
4	2	27	72	62	70	70	65	57	38	17
Average	1.3	22	68	64	67	67	65	55	29	14
					Basic plats planted in 1905					
9	10	65	70	67	62	67	62	72	67	35
10	10	77	72	67	57	67	62	80	75	35
11	20	90	80	60	62	65	82	95	90	40
Average	13	77	74	65	60	66	69	82	77	37
					Mildly acid plats planted in 1930					
5	7	65	77	77	77	77	72	72	55	22
15	3	52	80	70	70	70	77	72	60	20
16	3	62	75	75	75	75	80	80	62	20
Average	4	60	77	74	74	74	76	75	59	20

Figure 2, showing 3-inch cylindrical plugs removed to a depth of 18 inches and washed free of soil, indicates a great accumulation of dead roots on the highly acid plats (2 and 4). The basic plats (9 and 11) and the mildly acid plats (5 and 16) have much less accumulation of undecayed dead roots. The depth of the roots is unusually great for grasses clipped at a height of three-fourths inch. "Sod-bound" is the common term for an excessive accumulation of dead roots. The yield of clippings on the highly acid as compared with the mildly acid and basic plats was considerably less (Table 13).

In another series of plats (18 and 19, also 21 to 26, inclusive) the reaction varied as a result of previous treatments. These plats were divided into halves. On the west half (W) sulfate of ammonia was applied and on the east half (E) nitrate of soda was applied in amounts equivalent on a nitrogen basis. A weight of limestone equal to that of the sulfate of ammonia was mixed with it in order to hold the soil reaction constant.

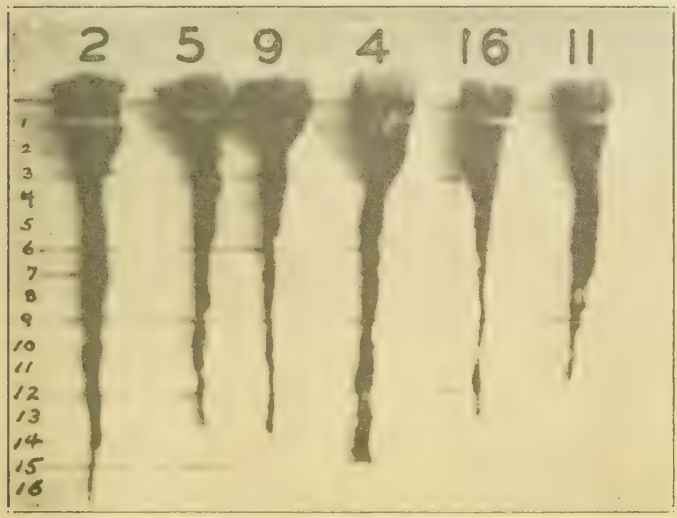

FIGURE 2. "Sod-bound" condition of turf.

Nos. 2 and 4—From highly acid plats, showing great accumulation of undecayed dead roots.
Nos. 5 and 16—From mildly acid plats.
Nos. 9 and 11—From basic plats, showing much less accumulation of dead roots.

On these plats, 1.76 pounds more nitrogen per 1000 square feet was supplied per season than to the highly acid, basic, and mildly acid plats described previously. This was done in order to increase the influence of the regular fertilizers. Arsenate of lead at the rate of 65 pounds per 1000 square feet was applied to plats 19, 22, 24, and 25 before planting in 1929. The results of this experiment are shown in Table 6.

This experiment was designed to show whether the weed control obtained on the highly acid plats 2, 3, and 4 was caused by the acid soil conditions induced or by the sulfate of ammonia itself. This subject is discussed more fully by Garner and Damon (4) in a previous summary of the results from these plats.

The average soil reaction was pH 4.98 for the set of plats in 1928. During the period of 1931 to 1936 inclusive, the average reaction was pH 6.04

TABLE 1 *Effect of soil reaction and fertilizer treatments on the quality of lawn plots at Rhode Island College, Kent Acres, the period from 1931 to 1935.*

Plot	Average reaction	Average ratings in factors of quality in per cent, 1931–1935					Average annual ratings in all factors of quality in per cent						Per cent of area in weeds		
	pH	Vigor	Color	Texture	Density	Uniformity	1931	1932	1933	1934	1935	Average	Seasonal average	Chick-weed	Crab-grass
Halves fertilized with sulfate of ammonia and limestone															
26 W	5.32	74	78	80	86	78	80	87	82	77	73	80	4.0	3.4	1.3
18 W	5.96	76	72	80	88	81	80	83	81	80	74	80	2.8	2.7	0.6
21 W	5.03	72	71	85	88	88	78	83	83	78	79	80	2.6	0.7	1.3
23 W	6.93	76	74	80	85	79	76	84	86	77	71	79	3.8	1.7	0.3
19 W*	5.54	79	68	82	81	82	78	81	83	76	63	78	2.0	0.8	0.8
22 W*	4.71	64	69	86	84	89	79	81	81	78	68	77	1.3	0.3	1.4
24 W*	5.88	68	64	80	76	74	74	81	84	73	50	73	4.0	1.0	1.6
25 W*	4.67	58	61	82	76	81	77	74	74	68	61	71	2.4	1.4	1.4
Average	5.12	71	70	82	83	81	78	82	82	76	67	77	2.9	1.4	1.1
Halves fertilized with nitrate of soda only															
23 E	7.00	80	75	76	82	77	75	84	85	75	71	78	6.0	2.8	3.2
18 E	5.93	80	73	72	80	70	71	83	75	74	74	76	4.8	3.5	2.6
26 E	6.03	72	70	74	77	69	72	77	71	70	73	73	7.0	4.5	3.1
21 E	5.86	73	68	69	72	74	69	65	72	72	76	71	6.0	2.6	6.5
19 E*	6.15	72	67	73	68	65	75	82	66	66	61	70	4.4	1.3	3.3
22 E*	5.74	67	62	75	70	70	76	69	70	65	62	68	3.6	1.3	4.8
24 E*	6.48	69	64	71	66	67	72	70	72	70	54	68	5.0	0.4	4.2
25 E*	5.84	67	60	70	62	63	73	64	59	60	68	65	5.0	1.2	5.0
Average	6.04	72	67	72	72	69	73	74	71	69	67	71	5.2	2.2	4.1

*Arsenate of lead applied at 65 pounds per 1000 square feet previous to planting.

for the nitrate halves, a decrease in acidity of approximately one pH unit. The sulfate of ammonia halves were changed very little (from pH 4.98 to 5.12). Apparently the changes in the turf are largely the result of the fertilizers themselves.

The ammonia halves were superior in color, finer in texture, denser, and more uniform than the nitrate halves. Annual ratings were as high or higher on each plat fertilized with ammonia rather than nitrate nitrogen excepting plats 24 and 25 in 1935. The figures indicate a gradual decline in quality on the nitrate halves. Better weed control, less disease, and less fertilizer injury occurred where the sulfate of ammonia rather than nitrate of soda was applied.

The effect of nitrate of soda and sulfate of ammonia on the amount of white clover in the turf is shown in Table 7.

TABLE 7. *The effect of soil reaction and fertilizer treatment on the amount of white clover in Colonial bent lawn turf during the period of* 1931 *to* 1935.

Plat	Treatment	Per cent of white clover						Reactions 1928	Reactions 1935	Average acidity (1932, 1933, 1935)
		1931	1932	1933	1934	1935	Average	pH	pH	pH
18 E	Nitrate of soda	18	8	6	3	7	8.4	6.51	6.13	5.93
18 W	Sul. am. + lime	16	3	2	3	7	6.2	6.51	5.66	5.96
19 E*	Nitrate of soda	11	4	3	2	5	5.0	6.08	6.02	6.15
19 W*	Sul. am. + lime	8	2	1	1	2	2.8	6.08	5.51	5.54
21 E	Nitrate of soda	8	10	7	3	3	6.2	4.90	5.68	5.86
21 W	Sul. am. + lime	7	4	2	2	2	3.4	4.90	4.99	5.03
22 E*	Nitrate of soda	4	4	2	2	3	3.0	4.28	5.66	5.74
22 W*	Sul. am. + lime	4	2	1	1	1	1.8	4.55	4.84	4.71
23 E	Nitrate of soda	17	6	2	2	4	6.2	7.03	6.51	7.00
23 W	Sul. am. + lime	13	4	2	1	4	4.8	7.03	6.53	6.93
24 E*	Nitrate of soda	12	5	3	1	2	4.6	5.81	6.53	6.48
24 W*	Sul. am. + lime	10	4	1	1	3	3.8	5.81	5.87	5.88
25 E*	Nitrate of soda	7	4	3	2	3	3.8	4.50	5.87	5.84
25 W*	Sul. am. + lime	4	1	1	0.5	0.4	1.4	4.50	4.79	4.67
26 E	Nitrate of soda	10	5	3	1	3	4.4	5.08	5.82	6.03
26 W	Sul. am. + lime	11	4	2	1	2	4.0	5.08	5.32	5.32

*Arsenate of lead at 65 pounds per 1000 square feet before planting.

The data indicate that for the average from 1931 through 1935 there was almost twice as much clover on the east halves (nitrate of soda) of plats 19, 21, 22, and 25 as on the west halves (sulfate of ammonia + lime). The other plats, in general, show a considerably larger per cent of clover on the nitrate halves. On all plats, regardless of the source of nitrogen the amount of white clover present has been greatly reduced with this heavy nitrogen fertilization.

Manure vs. mineral nitrogen

An experiment on Kentucky bluegrass turf, plats 7, 8, 13, and 14, involved treatments with sulfate of ammonia, nitrate of soda in a complete 8-6-6 fertilizer, nitrate of soda alone, and manure. In addition, during 1931 and 1932, extra organic nitrogen was applied on the west halves. Plats

TABLE 8. *Effect of fertilizer treatments and height of cut on Kentucky bluegrass turf during the periods 1931-1932 and 1933-1934 respectively.*

Plat	Fertilizer	Average ratings in factors of quality in per cent					Clippings per 1000 sq. feet (Lbs. per season)			Per cent of weeds				Worm casts
		Vigor	Color	Texture	Density	Uniformity	Average	Green	Air-dry	Total	Crab-grass	Chick-weed	Clover	No.
							No extra fertilizer—1931-1932							
13 E	Manure	54	71	72	68	....	66	....	....	8	11	3	24	31
14 E	8-6-6 Fert.	81	73	43	63	....	65	....	....	10	14	3	14	47
7 E	Sul. ammonia	68	65	61	68	....	65	....	....	8	7	4	31	18
8 E	Nit. soda	85	78	41	54	....	64	....	....	11	13	3	7	56
	Average	72	72	55	63	....	65	....	....	9	11	3	19	38
							Cottonseed meal extra—1931-1932							
13 W	Manure	60	74	70	75	....	69	....	....	9	13	3	26	41
14 W	8-6-6 Fert.	89	75	46	69	....	70	....	....	8	16	2	11	43
7 W	Sul. ammonia	73	70	57	74	....	68	....	....	17	8	4	25	26
8 W	Nit. soda	91	80	37	56	....	66	....	....	18	14	3	7	72
	Average	78	75	52	68	....	68	....	....	13	13	3	17	45
							Clipped at ¾ inch—1933-1934							
13 S	Manure	59	55	72	78	53	63	401	103	10	4	..	20	69
8 S	8-6-6 Fert.	66	50	42	54	29	48	410	109	17	10	..	20	65
14 S	Sul. ammonia	59	41	47	52	31	46	298	79	14	6	..	17	39
7 S	Nit. soda	51	45	46	45	24	42	269	70	14	4	..	24	26
	Average	58	57	52	57	34	50	344	90	14	6	..	20	50
							Clipped at 1¼ inches—1933-1934							
13 N	Manure	64	61	57	77	45	61	284	73	9	1	..	24	55
8 N	8-6-6 Fert.	68	53	31	52	34	48	257	69	15	10	..	23	50
14 N	Sul. ammonia	61	52	41	56	27	47	183	48	9	1	..	21	20
7 N	Nit. soda	64	51	29	47	26	43	203	51	15	2	..	36	13
	Average	64	55	40	58	33	50	232	60	12	3	..	26	34

7 and 13 were basic and plats 8 and 14 mildly acid due to previous liming and fertilizing. During the period from 1905 to 1928, plat 7 received a total of 460 pounds and plats 8, 13, and 14 received 92 pounds of lime per 1000 square feet. During the same period, plat 8 was top dressed heavily with manure. Plats 13 and 14 had nitrate of soda, and plat 7 received about equal amounts of sulfate of ammonia and nitrate of soda. The results obtained are shown in Table 8.

The results show that the manure and complete fertilizer plats on an average, were slightly superior to the others. Cottonseed meal added to the regular fertilizer in an amount calculated to supply one pound of nitrogen per 1000 square feet, improved the vigor, color, and density of the turf. The number of worm casts was increased also by the application of cotton seed meal. The protein in the cotton seed meal was apparently slowly changed to a form of nitrogen the grass could assimilate. It was applied for only two years.

During the years 1933 and 1934, the plats were divided into north (N) and south (S) halves by a difference in height of cut. From the results shown in Table 8, it may be seen that the turf mowed at 1½ inches was more vigorous and greener while the area cut at ¾ inch was somewhat finer although the different plats were equal in total quality. The ¾ inch height yielded approximately 50 per cent more weight of clippings but was more weedy. There was slightly more clover in the longer turf.

As an average of the period 1931 to 1934, the manured plat was higher in quality and contained a higher percentage of bluegrass than the other plats. These plats have shown that bent grasses tend to crowd out the bluegrass although conditions were supposedly favorable for the latter.

Activated sludge vs. mineral nitrogen

The effect on the turf resulting from the application of equivalent amounts of nitrogen in activated sludge, sulfate of ammonia, and nitrate of soda, in combination with phosphoric acid and potash applied in 1935 is shown in Table 9.

The quality ratings show that the organic fertilizer was somewhat superior to the mineral although the turf developed more slowly. The turf on the plats which had received manure in previous years produced the better growth as determined by estimates of vigor, vacant area, and weights of clippings. Nitrate of soda favored the growth of chickweed except on plat 7.

EFFECT OF PHOSPHORUS AND POTASH

Although nitrogen is the fertilizer ingredient that produces the most striking response on turf, a certain amount of phosphoric acid and potash are also necessary. The phosphoric acid especially tends to promote a good root growth. A liberal amount of phosphoric acid in the form of superphosphate or other similar material should be worked into the soil before the new lawn is planted.

TABLE 9. *Effect of different nitrogen fertilizers on Kentucky bluegrass lawn plats the first season after planting.*[1]

Plat[2]	Average ratings in factors of quality in per cent						Clippings per 1000 sq. ft.		Vacant area	Leafspot (% area)	Per cent of weeds		
	Vigor	Color	Texture	Density	Uniformity	Average	Green	Air dry			Total	Chick-weed	Crab-grass
							(pounds)		%				
Activated sludge													
13 C	78	76	60	48	86	70	67	21	18	5.0	3.5	1.5	2.5
8 C	82	78	48	38	80	65	100	30	30	0.5	6.2	1.0	0.5
7 C	72	74	56	34	88	65	63	19	32	1.5	4.5	1.0	3.0
14 C	70	68	50	38	90	63	62	21	38	trace	8.7	4.0	0.1
Average	75	74	53	39	86	66	73	23	29	1.7	5.7	1.9	1.5
Sulfate of ammonia													
13 S	80	78	54	48	84	69	90	28	17	7.5	3.7	1.0	2.0
8 S	84	76	40	34	74	62	103	30	30	1.5	6.2	trace	3.0
7 S	72	72	50	34	84	62	65	19	30	3.5	7.0	3.0	1.0
14 S	74	70	48	36	88	63	76	24	35	0.5	8.5	2.0	0.1
Average	77	74	48	38	82	64	83	25	28	3.2	6.3	1.5	1.5
Nitrate of soda													
13 N	80	76	52	44	84	67	69	21	17	10.0	4.5	2.5	0.1
8 N	84	78	40	32	78	62	89	28	26	2.5	9.2	5.0	2.0
7 N	72	72	46	30	84	61	36	11	31	5.0	5.5	trace	0.1
14 N	74	71	46	40	84	63	80	23	31	1.0	15.0	15.0	0.3
Average	77	74	46	36	82	63	68	21	26	4.6	8.5	5.6	0.6

[1]Planted September 20, 1934. (Plat 13 a solid turf in July, 1935. Plats 7, 8, and 14 a solid turf in August, 1935.)
[2]North, center, and south one-thirds.

Plats 8 and 13 (Table 9), which have received both phosphoric acid and potash in the fertilizer applied, show a higher quality and more vigorous turf than plats 7 and 14 where, until recent years, only small amounts or none of these ingredients were added.

Old Lawn Renovation

Four plats, 6, 12, 17, and 20, were used to determine the value of topdressing old turf with compost in order to improve its quality and vigor. Manure compost at the rate of 1 yard per 1000 square feet was applied to the west (W) halves from 1929 to 1932, and steam sterilized compost similarly applied to the east (E) halves from 1933 to 1935. The results are shown in Table 10.

The five year averages of vigor, color, texture, density, uniformity, and clipping weights show the unsteamed and steamed compost nearly equal in their effects on the quality of the turf. The total effect of compost as compared with no compost is rather plainly shown by the differences in ratings during 1931 and 1932. The ratings for 1935 show that the areas composted during the period from 1929 to 1932, but not since 1932, are gradually deteriorating although not as rapidly as might be supposed.

The acid turf of plats 6 and 20 have shown the greatest response to compost. The greatest need for topdressing is shown by the Washington creeping bent turf planted with stolons in 1925. Colonial bent was superior to the creeping bent and also the Kentucky bluegrass mixture during this period.

WEEDS AND THEIR CONTROL

Preventive Measures

A good program of turf management is the best security from the invasion of weeds. Some of the measures taken in these experiments in order to control weeds include the following: clean cultivation of the seed bed area before planting; seeding in early autumn (a lawn properly planted in autumn usually remains relatively free from weeds if well maintained); the use of pure seed; the use of clean topdressing which is free of weed seeds and rootstocks (this was accomplished by sterilizing the soil with steam); and proper and ample fertilization. If these measures are neglected, the weed problem is quite apt to become serious. Occasionally annual and biennial weeds occur in a fall-seeded lawn; however, most of these will be killed by frost or under close cutting in the spring. Prevention is much easier than eradication in the case of weeds, although considerable progress has been made at this and other stations in the rapid and inexpensive eradication of lawn weeds.

Some of the common weeds which have given trouble in the new lawns are: common chickweed, carpet weed, spurry, ragweed or wormwood, foxtail (yellow), witchgrass, or quackgrass.

TABLE 10. *Influence of renovation* on old lawn plats as measured by the turf quality and clippings during the period 1931 to 1935*

Plat	Treatment**	Average ratings in factors of quality in per cent					Average annual ratings in all factors of quality in per cent						Clippings in pounds per 1000 sq. ft.	
		Vigor	Color	Texture	Density	Uniformity†	1931	1932	1933	1934	1935	Average	Green	Air dry
						Washington Creeping Bent Grass (acid)								
6 W	Compost 1929-1932	54	63	71	71	81	62	63	77	74	57	67	178	52
6 E	Compost 1933-1935	53	60	75	61	85	52	51	74	78	67	64	191	51
	Difference in favor of compost						10	12		4	10			
						Rhode Island Colonial Bent Grass (acid)								
20 W	Compost 1929-1932	60	72	85	79	85	72	73	78	78	74	75	238	77
20 E	Compost 1933-1935	58	64	85	75	78	57	69	74	78	75	71	240	78
	Difference in favor of compost						15	4		0	1			
						New Zealand Colonial Bent Grass (neutral)								
12 W	Compost 1929-1932	68	78	80	84	87	76	77	87	82	72	79	221	64
12 E	Compost 1933-1935	67	76	80	81	89	70	73	84	83	75	77	203	59
	Difference in favor of compost						6	4		1	3			
						Kentucky Bluegrassbent grass mixture (base)								
17 W	Compost 1929-1932	80	74	57	72	63	72	61	70	73	71	69	243	68
17 E	Compost 1933-1935	75	77	59	72	63	64	62	75	70	73	69	221	61
	Difference in favor of compost						8	1			2			

*In the autumn of 1932 and 1933 two applications of sulfate of ammonia at the rate of 3 pounds per 1000 sq. ft. were made, mixed with compost.

**Manure compost at the rate of 1 yd. (approximately 10 wheelbarrow loads) per 1000 sq. ft.

†1933 to 1935.

These and other common garden weeds have caused little difficulty during the second and succeeding seasons when kept down by frequent clipping.

Weeds that have been troublesome both in the new and in the established lawns are: mouse ear chickweed, crabgrass or finger grass, common dandelion, fall dandelion, broad leaf plantain, narrow leaf plantain, heal-all, yarrow, and sheep sorrel.

General Control Methods

A desirable control has been found for both chickweed and crabgrass (Tables 11 and 12). Chickweed and practically all other weeds except crabgrass have been controlled by the soluble and toxic aluminum of the soil in highly acid lawn plats as shown by Hartwell and Damon (*6*), also Garner and Damon (*4*). However, it is more desirable to kill the weeds without resorting to highly acid soil conditions as shown by Sprague and Evaul (*13*). This is supported by evidence from the ratings in turf quality of plats with different degrees of acidity as discussed previously (Table 6).

The work of Gilbert and Pember (*5*) at the Rhode Island Agricultural Experiment Station gives definite information on the tolerance of weeds and grasses to aluminum when grown in solution cultures. The authors classified the plants grown as follows: sensitive group (growth depressed as much or more than 20 per cent by 2 to 8 parts of aluminum per million in solution), mouse ear chickweed, common chickweed, common dandelion, yellow foxtail, heal-all, and Kentucky bluegrass; medium sensitive group (growth depressed as much or more than 20 per cent by 16 to 32 parts of aluminum per million in solution), fall dandelion, and smooth crabgrass; resistant group (growth depressed as much or more than 20 per cent by 32 to 80 parts of aluminum per million), rough or large crabgrass, redtop, and colonial bent.

The results of the lawn experiments indicate that yarrow may be in the sensitive or medium group. Sorrel and cinquefoil are probably in the resistant group. It is highly significant that Kentucky bluegrass was found to belong in the sensitive group. Obviously the acid soil method cannot be used for control of weeds in the bluegrass lawn.

Fall dandelion and crabgrass are shown to be capable of growth in medium acid to highly acid soils in which soluble aluminum is usually present. Most of the other weeds are less tolerant of aluminum than is colonial bent grass.

Individual Control Measures

Arsenate of lead compared with iron and aluminum sulfate

The weed control obtained on plats 6, 12, 17, and 20 by the application of arsenate of lead, iron sulfate, and aluminum sulfate is shown in Table 11 for the period from 1931 to 1935. Arsenate of lead was applied only in 1931 at the rate of 9 pounds mixed with 3 12-quart pails of soil per 1000 square feet. Iron and aluminum sulfates were applied in May and August at the rate of 3 pounds and in 1932 and 1933 at the rate of 1 pound per

1000 square feet. The sulfates were not removed from the leaves by watering since moderate burning was desired. It is evident from results shown that the application of arsenate of lead reduced the weeds much more than the iron or aluminum sulfate.

TABLE 11. *Weed control obtained in lawn turf by the application of fertilizer*, iron sulfate, aluminum sulfate, and arsenate of lead, for the period from* 1931 *to* 1935. *Figures show estimated per cent of weeds in different plats. West halves received unsterilized compost annually,* 1929-1932; *east halves received sterilized compost annually,* 1933-1935.

Treatment	1931 June	1931 Oct.	1932†	1933†	1934†	1935†	1931 June	1931 Oct.	1932†	1933†	1934†	1935†
					Plats 6 and 20 (acid)							
Check	12.5	18.5	9.0	8.1	4.9	4.6	15.0	6.0	3.5	3.3	4.8	**3.7**
Arsenate of lead—1932**	12.5	18.5	5.0	**2.7**	**0.6**	**0.2**	15.0	6.0	1.3	**1.7**	**2.6**	**0.9**
Iron sulfate‡	10.0	6.0	4.5	8.1	4.0	9.3	12.5	5.5	1.3	8.2	9.5	1.9
Aluminum sulfate‡	11.5	7.5	5.5	6.2	3.2	6.0	10.0	4.0	1.0	3.1	4.5	2.5
Arsenate of lead—1931**	12.5	**6.0**	**2.0**	**2.4**	**0.2**	**0.3**	10.0	**2.5**	**0.6**	**0.6**	**0.6**	0.3
					Plat 12 (neutral)							
Check	10.0	10.0	5.2	10.7	4.5	11.8	20.0	8.0	4.2	3.7	3.7	3.0
Arsenate of lead—1932	10.0	10.0	3.7	**2.7**	**1.0**	**1.6**	20.0	8.0	1.0	**0.0**	**1.2**	**0.6**
Iron sulfate	8.0	7.0	3.0	10.0	2.7	9.5	15.0	4.0	1.0	4.7	2.5	4.5
Aluminum sulfate	7.0	7.0	2.7	5.7	4.2	8.4	15.0	6.0	1.7	3.2	5.2	5.5
Arsenate of lead—1931	10.0	**5.0**	**1.5**	**2.2**	**2.2**	**5.2**	10.0	**6.0**	**1.5**	**1.0**	**0.5**	**0.9**
					Plat 17 (basic)							
Check	15.0	40.0	40.0	27.5	11.0	20.0	30.0	30.0	25.0	18.7	11.5	14.0
Arsenate of lead—1932	15.0	40.0	26.1	**5.5**	2.0	5.8	30.0	30.0	35.0	**20.0**	8.0	10.3
Iron sulfate	15.0	35.0	40.0	32.0	11.7	17.8	25.0	50.0	35.0	27.5	15.0	12.3
Aluminum sulfate	20.0	25.0	17.9	28.7	12.2	13.3	10.0	10.0	19.0	16.2	8.5	9.8
Arsenate of lead—1931	10.0	**5.0**	**2.2**	**3.0**	2.5	1.9	3.0	**4.0**	**0.5**	**1.2**	2.5	1.5

*In 1932 and 1933, each application of iron sulfate or aluminum sulfate was mixed with 3 pounds of sulfate of ammonia per 1000 square feet. Sulfate of ammonia was also applied to the check and arsenate of lead subplats.

**Applied at the rate of 9 pounds per 1000 square feet.

†Average of estimates made in April, June, August, and October.

‡Applied in May and August 1931, at 3 pounds and in 1932-1933 at 1 pound per 1000 sq. ft.

Figures in bold faced type represent weed population free from chickweed.

The turf was not injured by the arsenate of lead but was injured slightly by the iron and aluminum sulfates the latter reduced the vigor of the uncomposted acid turf and the iron sulfate caused a temporary unsightly black appearance.

The effect of the arsenate of lead was more pronounced on the acid turf, as the chickweed was completely killed the first year after treatment and did not reappear during the four succeeding years. Chickweed and other weeds were less completely eliminated in the neutral and alkaline plats. Very good results were secured with the arsenate of lead at a cost of approximately one dollar per 1000 square feet of area for the material.

Arsenate of lead compared with sodium arsenite

In April, 1935, sodium arsenite was applied at the rate of 4 ounces in 10 gallons of water as a spray and the arsenate of lead at 10 pounds mixed with soil per 1000 square feet. There were two subplats left untreated as checks on each of the twelve plats treated. The results obtained are shown in Table 12.

The sodium arsenite injured the turf temporarily and this injury may have allowed more crabgrass to come in but arsenate of lead had no injurious effect. The treated areas had a higher seasonal rating than the checks.

Sodium arsenate killed the mouse-ear chickweed in approximately one month's time. By August, the arsenate of lead subplats were relatively free of chickweed. The control of chickweed, as an average of all subplats, was 88 per cent for the sodium arsenite and 80 per cent for arsenate of lead. Crabgrass was more prevalent where sodium arsenite was applied but it was greatly reduced by the arsenate of lead treatment. It is believed that the arsenate of lead delays the germination of the seeds for some time. As an average of all plats, the control was 80 per cent with lead arsenate. Greenkeepers have been using this method for the control of chickweed for several years.

The control of total weeds during the season was 66 per cent for arsenate of lead and 32 per cent for sodium arsenite. Sodium arsenite, applied in the fall rather than spring, would probably not injure the turf and hence not encourage the entrance of crabgrass. It is also an herbicide of great value for other weeds and is very inexpensive. The material to treat an acre costs only one dollar when applied at the rate of 4 ounces per 1000 square feet.

CAUTION: Sodium arsenite is extremely poisonous and must be even more carefully handled than arsenate of lead. It is a wise precaution to cover the mouth and nose with a handkerchief if much spraying is to be done.

Fertilizing

It is surprising how few common weeds can compete with properly fertilized grass. This method has been very effective in the sparsely grassed, neglected lawn turf. Where the fertilizer has consisted of a high nitrogen mixture and especially where the nitrogen has been supplied as sulfate of ammonia, the control has been highly satisfactory.

WORMS, INSECTS, AND OTHER PESTS

Fortunately, the insects causing noticeable damage to lawns in Rhode Island are few, the worst offenders being earthworms, ants, and June beetle and Japanese beetle grubs. Webworms and cutworms may cause trouble occasionally. North and Thompson (9) found that lead arsenate applied at the rate of 2 pounds per 1000 square feet of turf effectively controlled webworms.

TABLE 12. *Effect of sodium arsenite and arsenate of lead treatments on lawn weeds and turf during the season of 1935.*

Plats	Per cent of weeds									Quality rating of turf in per cent		
	Crabgrass Aug. 13			Chickweed Aug. 13			Total Weeds—(Season)					
	Check	Sodium arsenite*	Arsenate of lead	Check	Sodium arsenite	Arsenate of lead	Check	Sodium arsenite	Arsenate of lead	Check	Sodium arsenite	Arsenate of lead
Acid												
2	9.0	12.0	0.5	0.60	0	0	3.5	4.5	0.5	62	64	64
3	7.5	10.0	0.1	0.30	0	0	2.5	3.6	0.5	64	64	64
4	8.5	10.0	0.5	0.05	0	0	2.3	3.4	0.4	68	68	69
Average	8.3	10.7	0.3	0.30	0	0	2.9	3.8	0.5	65	65	66
Control	0	–29	96	0	100	100	0	–31	83			
Mildly Acid												
5	0.9	3.0	0.10	9.5	5.0	2.0	8.6	4.3	4.0	66	68	69
15	0.6	2.0	0.05	6.5	0.1	0.2	6.6	1.3	2.5	69	70	72
16	0.2	0.2	0.05	6.0	1.5	1.0	5.5	1.7	3.5	71	72	74
Average	0.6	1.7	0.07	7.3	2.2	1.1	6.9	2.4	3.3	69	70	72
Control	0	–183	88	0	70	85	0	65	52			
Basic												
9	5.0	7.0	4.0	30.0	1.0	10.0	33.5	11.0	21.7	52	59	58
10	5.5	9.0	2.0	29.5	2.0	8.0	28.7	10.0	16.7			
11	5.0	6.0	1.0	12.5	0.5	1.0	12.5	6.7	4.7	64	72	72
Average	5.2	7.3	2.3	24.0	1.2	6.3	24.9	9.2	14.4	58	65	65
Control	0	–40	56	0	95	74	0	63	42			
Average of all plats	4.7	6.6	0.9	10.5	1.1	2.5	11.2	5.1	6.1	64	67	68
Average of Control plats	0	–84	80	0	88	86	0	32	66			

*Sodium arsenite injured the turf temporarily and this injury undoubtedly allowed more crabgrass to come in

EARTHWORM CONTROL

While earthworms are considered desirable in cultivated fields, the deposits of soil at the mouth of their burrows make a lawn bumpy and unsightly. Earthworms abound in heavy, fertile, non-acid soils, and are usually least numerous in sandy soils.

TABLE 13. *Effect of soil reaction and treatments with arsenate of lead on the number of earthworm casts per square yard and on weight of clippings in pounds during the period from* 1931 *to* 1935.

Plat	Average Reaction (1932, 1933, 1935)	Worm casts per square yard					Group ave.	Clippings per 1000 square feet 1933-1935		Average	
		1931	1932	1933	1934	Ave.		Green	Air dry	Green	Air dry
2	pH 4.22	0.0	0.0	0.5	0.0	0.1		150	49		
3	4.24	0.0	0.0	0.5	0.0	0.1		176	55		
4	4.33	0.0	0.0	0.0	0.0	0.0	0.1	173	56	166	53
6	4.57	14.0	15.0	23.0	....	17.0*		184	51		
1	4.67	0.0	1.0	0.0	0.0	0.2		195	58		
25 W	4.67	0.0	5.0	0.0	5.0	2.0**		201	61		
22 W	4.71	0.0	0.0	0.5	3.0	1.0**	5.0	195	61	194	58
21 W	5.03	0.0	5.0	64.0	54.0	31.0		205	61		
20	5.17	2.0	4.0	31.0	....	13.0*		239	77		
5	5.18	10.0	7.0	51.0	35.0	26.0		224	64		
30	5.20	0.0	3.0	0.0	1.5	1.0		208	61		
27	5.21	1.0	1.0	0.5	55.0	14.0		218	67		
29	5.28	0.0	4.0	0.0	48.0	13.0		182	57		
26 W	5.32	2.0	10.0	57.0	77.0	36.0		232	71		
28	5.36	3.0	3.0	0.5	51.0	14.0	18.0	205	60	225	65
19 W	5.54	0.0	1.0	3.0	10.0	4.0**		233	71		
22 E	5.74	0.0	5.0	0.5	4.0	2.0**		205	60		
16	5.77	3.0	16.0	29.0	22.0	17.0		247	67		
25 E	5.84	0.0	3.0	3.0	5.0	3.0**		224	64		
21 E	5.86	1.0	2.0	65.0	65.0	33.0		224	62		
24 W	5.88	0.0	1.0	0.5	9.0	2.0**		222	67		
18 E	5.93	3.0	50.0	69.0	75.0	49.0		187	50		
18 W	5.96	4.0	46.0	83.0	63.0	50.0	39.0	230	66	221	63
26 E	6.03	4.0	7.0	62.0	140.0	53.0		217	64		
15	6.10	11.0	18.0	37.0	27.0	23.0		239	68		
19 E	6.15	0.0	2.0	1.0	6.0	2.0**		243	70		
8	6.15	38.0	90.0	82.0	14.0	56.0		333†	89		
14	6.40	21.0	69.0	42.0	62.0	48.0		240†	63		
24 E	6.48	0.0	1.0	2.0	9.0	3.0**	45.0	220	63	249	69
23 W	6.93	2.0	3.0	81.0	90.0	44.0		208	59		
23 E	7.00	1.0	5.0	76.0	128.0	52.0		225	59		
12	7.03	18.0	25.0	79.0	....	41.0*		214	61		
7	7.46	18.0	26.0	25.0	....	23.0		236†	60		
10	7.53	13.0	55.0	35.0	54.0	39.0	40.0	249	63	226	60
13	7.55	21.0	51.0	68.0	36.0	44.0		342†	88		
9	7.61	14.0	20.0	34.0	50.0	29.0		233	63		
11	7.64	22.0	38.0	33.0	66.0	40.0		230	67		
17	7.70	18.0	48.0	82.0	....	50.0*	41.0	232	64	261	70

*Compost applied.
**Arsenate of lead applied in 1929.
†1931 results only.

The counts of earthworm casts per square yard on the lawn plats during the past few years (Table 13) show that the soil reaction determines, to a great extent, the number of earthworms that will be present. In plats with a reaction as low as pH 4.2 to 5.0, the earthworms were scarce unless compost had been applied recently. From pH 5.0 to 6.0 there were more casts, and reactions of pH 6.0 to 7.7 permitted large populations.

Mineral fertilizers have been found unfavorable to earthworms as compared with organics such as manure.

In an experiment on the control of earthworms during 1932, arsenate of lead was compared with bichloride of mercury, mowrah meal, a patent worm eradicator, and tobacco fertilizer (tobacco waste). The tobacco waste applied at a heavy rate gave moderate transitory control, arsenate of lead at 2 ½ to 10 pounds per 1000 square feet gave good control while the other materials were rather ineffective. These materials were applied dry and not dissolved by watering; however, a heavy rain fell the evening following the application.

TURF GRASSES

A comparison of the adaptability of a number of different grasses for lawns is afforded in these experiments. Additional tests at this station and at other experiment stations have also yielded much information on the most suitable grasses for lawns and other turf under different soil and climatic conditions. The discussion of the adaptability and general character of the different turf plants will be based on data both from the tests described in this bulletin and on the other experiments mentioned.

In Table 14 are shown the quality ratings of five plats seeded with various mixtures as well as Rhode Island Colonial bent alone.

TABLE 14. *The quality of lawn plats planted in* 1929, *during the period from* 1931 *to* 1935.

Plat	Average ratings in factors of quality in per cent					Average annual ratings in all fatcors of quality in per cent						Weeds	Clover
	Vigor	Color	Texture	Density	Uniformity	1931	1932	1933	1934	1935	Average	per cent	per cent
27	78	84	81	88	84	84	84	86	81	79	83	2.1	5.5
29	71	74	87	90	87	82	84	85	77	79	81	2.4	2.9
28	67	69	83	85	81	80	79	82	74	70	77	2.0	3.2
30	79	79	72	80	71	79	80	76	73	76	77	5.4	2.8
1	68	69	80	79	77	80	72	76	76	69	75	6.0	2.3

Plat 27—Largely colonial and velvet bent; Kentucky bluegrass and white clover planted.
Plat 29—Rhode Island Colonial bent; Rhode Island Colonial bent planted.
Plat 28—Rhode Island Colonial bent; Rhode Island Colonial bent planted.
Plat 30—R. I. Bent and Kentucky Bluegrass; Kentucky bluegrass and European red fescue planted.
Plat 1—R. I. Bent and Sheep fescue; Kentucky bluegrass and European red fescue planted.

It may be seen from these results that Rhode Island Colonial has been one of the most persistent grasses in this comparison. It has become established in plats even where it was not originally seeded. This has been the case with other plats also as shown in other data presented in previous tables.

BENT GRASSES

The cultivated bent grasses have been found to be particularly well adapted to the climate and soil of Rhode Island and to the making of lawns. They became naturalized in Colonial times and early became the dominant turf and pasture grasses in New England. This is particularly true of Colonial or Rhode Island bent. The bent grasses are all capable of forming continuous turf because of their ability to creep. Bent grasses are noted for tolerance of conditions of acid soil, low fertility, and close clipping. However, previous experiments have shown these grasses highly responsive to fertilizing, composting, and watering and only moderately responsive to liming. The seeds are very small, five to ten million per pound, and difficult to identify.

COLONIAL BENTS (*Agrostis tenuis, Sibth*)

Rhode Island bent has been the common name for this species because it first became well established and recognized on the North American continent in Rhode Island. Other common names include: browntop, German bent, burden grass, fine bent, and Waipu bent. With ordinary care, it forms an excellent lawn except in dense shade and in very wet or very drouthy soils. The growth is fine, dense, moderately vigorous, upright, and uniform. The turf has a bright medium green color becoming green later in the spring and browning earlier in the autumn than Kentucky bluegrass. A lawn of Colonial bent properly made, fertilized, and cared for will live indefinitely without reseeding. The plants spread rapidly by means of overground stems and not infrequently by short underground stems. Brown-patch disease attacks Colonial bent, but usually is of minor importance in lawns in Rhode Island. The seedling growth is approximately as rapid as redtop and no nurse grass is required when properly planted in late summer.

Astoria bent, which consists of a large proportion of plants with subsurface creeping habit, is produced in Oregon. The turf is more yellow-green than other Colonial bents.

Highland, Oregon, or Dryland Colonial bent plants in our nursery have sent out deep-growing underground stems. It also creeps above ground. The leaves resemble redtop in color and at hay length are somewhat narrower than other types of Colonial bent. Hillman (*17*) has shown that the seeds are readily distinguished from the other forms of Colonial bent. In plats on an athletic field it has done poorly. It grows best in cooler weather and has been found drouth resistant by other investigators.

VELVET BENT (*Agrostis canina L.*)

Velvet bent has been found by Reid (*12*) to be more tolerant of acid soil and shade than Colonial or creeping bents. In Rhode Island it has been similar to Colonial bents in resistance to drouth. It succeeds better than Colonial or creeping bents where the drainage is poor. It has also been less subject to weed encroachment.

There is a wide variation in the turf forming qualities of the numerous vegetative strains of velvet bent. The supply of pure seed is very limited

At present, seed is being produced in Rhode Island, New Jersey, and Oregon. Several farmers in Rhode Island are now growing seed of the particularly desirable strains, Piper (B. P. I. 14276) and Kernwood. It is possible to grow velvet bent turf from vegetative material (stolons) although the expense is considerably higher than when seed is used.

Velvet bent turf maintains a brilliant color, very fine texture, exceptional density, and good wearing qualities when well managed. Its maximum beauty is revealed under close clipping and an occasional topdressing with screened compost.

CREEPING BENTS (*Agrostis palustris, Huds*)

A few forms are cultivated, one propagated by seeds and the others by stolons. The former has been called Seaside Creeping bent and the latter include a number of vegetative strains, the best known of which are Metropolitan and Washington. Both forms have proven much less tolerant of drouth, acid soil conditions, and neglect, than Colonial and velvet bents. Reid (12) found Metropolitan creeping bent less tolerant of shade than velvet bent. Composting is almost imperative in order to preserve the vigor of this turf in Rhode Island, although periodic raking will do much to reduce the accumulated tangle of stems. These bents are very rapid overground creepers forming a bright, fine, dense, and uniform turf. They have been found susceptible to snowmold.

Seaside creeping bent may be found growing in brackish water and apparently thrives best where water stands during the winter, particularly where silt gradually accumulates. Seedling growth has been found to be as rapid as redtop.

Metropolitan and Washington stolon strains have proven highly resistant to leafspot diseases but the Washington, while resistant to brownpatch, is susceptible to dollarspot. Metropolitan is moderately susceptible to brownpatch. Little, if any, seed of these strains is produced. Although seldom planted with seed, growth has been found approximately as rapid as velvet bent in the seedling stage. A turf is produced very rapidly from stolon plantings.

REDTOP AND MIXED BENTS (*Agrostis species*)

Redtop (*Agrostis alba, L.*) is often found growing in regions where the finer bent seeds are produced. Since redtop forms a coarse turf, the growers of fine bents permit only a trace of redtop in the fields harvested for seed. Redtop is short lived in competition with better turf grasses and although rated as a nurse grass, it grows rather slowly in the seedling stage. It is best adapted in a mixture. When sown alone the turf produced is coarse, open, gray-green, and not desirable for a lawn. Redtop creeps by means of underground stems. It possesses considerable resistance to drouth. Lawn mixtures labelled as containing *Agrostis species* usually contain redtop.

Mixed bent seed has been produced largely in Germany, also in Rhode Island, Prince Edward Island, and Oregon. It is composed largely of Colonial and velvet bents. German bent may contain redtop, creeping bent and black bent, (*Agrostis nigra*) according to Hitchcock (*8*). It is well adapted to Rhode Island and forms turf much the same as Colonial bent for the first few years. Mixed bent like mixtures of other lawn seeds, will give rise to a mottled appearance and finally to patches which may or may not be pleasing.

BLUEGRASSES

Bluegrasses make up a considerable portion of the improved pastures and lawn turf of the State. They may be identified by the tips of the leaves which are blunt and boat-shaped. In comparison with Colonial bent, bluegrasses grow best in cooler weather, and stand up under heavier wear although they are less able to compete on acid soils and under close clipping. Bluegrasses have not been susceptible to brownpatch or dollarspot, although leafspot has been troublesome.

Kentucky Bluegrass (*Poa pratensis, L.*) is the most important of the cultivated bluegrasses in the northeast. In the lawn plats, bluegrass was found by Hartwell and Damon (*6*) to die out rather generally on the acid plats and to flourish on the neutral and basic plats. Sprague (*13*) has shown that under conditions of high acidity Kentucky bluegrass absorbed less lime material than Colonial bent. Kentucky bluegrass is well adapted and permanent for lawns, providing an attempt is made to improve the soil. The turf is dark green, medium textured, upright, and uniform when free from weeds and other grasses. Although producing a vigorous growing turf, it has been found to be less dense and more subject to invasion by weeds than the better strains of the bents. The grass persists in moderate shade. The turf has been improved by organic fertilizers. Kentucky bluegrass forms a good turf when planted in late summer without a nurse grass and has been recommended by this station in combination with colonial bent. The grass is particularly desirable for play areas in the back yard, school grounds, and athletic fields. The seed is usually of medium quality as it may be low in germination. The better grade of seed weighs from 24 to 27 pounds per bushel. Seedling growth is faster but germination slower than Colonial bent, thus the early growth of the two are similar.

Canada Bluegrass (*Poa compressa, L.*) is easily distinguished from Kentucky bluegrass by the wider gray-green leaves and flattened stems. It has been found unsuited to the production of close turf in a lawn because, as Evans and Ely (*3*) have shown, the growing point gradually rises to approach the height of ordinary lawn clipping. It tillers very slowly in spring and summer. It may be used in more or less naturalized areas too poor for Kentucky bluegrass. The grass spreads by means of subsurface creeping stems. Seed is of good quality and may be included in that of Kentucky bluegrass as an adulterant. Under similar conditions the growth in the seedling stage was slower than velvet bent and germination was very slow.

Rough bluegrass (*Poa trivialis, L.*) is better adapted to shade than

other bluegrasses. Soil requirements are similar to those for Kentucky bluegrass, which it resembles. However, the grass has a medium, yellow-green color and spreads above ground much as non-creeping Colonial bent. It forms a beautiful turf in the shade of buildings, withstands close clipping and remains green in cold weather. It grows so poorly in open sun that it was not successfully established in the lawn plats. It is considered the best grass in the shade of trees in moist situations where the soil is suitable.

Annual bluegrass (*Poa annua, L.*) is well adapted to the climate and soil of Rhode Island where it forms a brilliant, light green turf which withstands close clipping, hard wear, and dense shade, particularly during fall, winter, and spring. Seed is produced more or less continuously, particularly during cool weather, by means of which the older plants are replaced. The grass creeps above ground like rough bluegrass. Annual bluegrass grows during cold weather and may become a most popular grass for reseeding worn turf in athletic fields during the autumn. The grass has been susceptible to snowmold and leaf spot diseases. In case of severe injury the seedlings grow to cover the scars rather quickly.

FESCUES

The name *Festuca* means a weedy grass which indicates extreme persistence and hardihood under unfavorable conditions. The lawn fescues survive on soils too dry for bent or bluegrass, grow on acid or basic soils, grow in cold weather and require a minimum of care. However, under adverse conditions they may become bunchy and dull colored. They will grow in dry soil and in dense shade where other grasses die out. Fescues withstand close clipping better than bluegrass and, with the exception of meadow fescue, produce fine bristle-shaped leaves. Seeds are approximately five times as large as those of bluegrass. The fescues are very hard to clip unless well shaded and are best cut with a sharp power mower.

Red Fescue (*Festuca rubra, L.*) has formed a fine, dense, uniform turf, relatively free from weeds and clover as shown in Table 8. Plats 4 and 11 have not been weeded or reseeded during the past 30 years. The color rating of this turf at different seasons is shown in Table 7. The seed is sold under several variety names. The red fescues seem to offer exceptional opportunities for selection of strains improved in summer greenness, creeping habit, and easy clipping. Chewing's Fescue (*var. commutata Gaud.*) seed is produced in New Zealand and Oregon. Seedling growth has been approximately one half as rapid as Italian ryegrass.

Sheep Fescue (*Festuca ovina*) is not a good lawn grass but will persist indefinitely on poor gravelly soils and in shade. The leaves are gray-green and wirey. This fescue may be used for naturalized planting where the bunchy growth is not an objection.

RYEGRASSES

Ryegrasses are desirable nurse grasses for spring and late autumn plantings. If clipped early and frequently enough, the permanent grasses are not injured by shading and weeds are effectively checked. Ryegrasses

are particularly valuable in mixtures for steep slopes and athletic fields where a quick growth is desired. The seed is inexpensive, about twice as large as fescue seed, and relatively pure and viable. Ryegrass seeds germinate very quickly.

Perennial Ryegrass (*Lolium perenne*, *L.*) was the first meadow grass to be cultivated in Europe as a segregated species. Plantings have indicated that a majority of the plants die out by the end of the second season, and often before. Occasionally true perennial plants are very difficult to mow, remaining as coarse glossy leaved patches for many years. There are a number of strains of perennial ryegrass which may in time become highly useful for playgrounds. A comparison of ryegrass and redtop as nurse grasses for late planting proved the ryegrass much superior to the redtop. Pacey's ryegrass, as received in this country, is merely the small seed of perennial ryegrass separated out mechanically.

Italian Ryegrass (*Lolium multiflorum*, *Lamb.*) lives only one complete season, and therefore is often more desirable for a nurse grass than the perennial types.

DISCUSSION AND CONCLUSIONS

The results reported in the bulletin indicate very clearly the necessity of giving a lawn proper care if a satisfactory turf is to be obtained.

Based on the results in these experiments, as well as other tests at this and other stations, the following suggestions are made with regard to fertilizers, liming, seeding, and the control of certain lawn pests.

FERTILIZERS

A number of different fertilizer materials and combinations were compared. Considerable variation was shown in the results obtained with different treatments. In general, fertilizers with a high nitrogen content have given the best results and are recommended. In order that the fertilizer may have a prolonged and gradual effect, part of the nitrogen should be in an organic form. Some suggestions on fertilizer materials and methods of application follow.

(A) Fertilizers for applying either in early spring or fall or at both times:

(1) Complete commercial fertilizer. Usually a complete fertilizer high in nitrogen should be satisfactory such as a 10-6-4, 8-6-6, 12-6-4, or a 8-6-4. If the nitrogen is partly organic it is more valuable. From 10 to 20 pounds per 1000 square feet is a usual early spring application but not more than 10 pounds should be used in the fall unless watered-in.

(2) Complete home-mixed fertilizer. It is usually somewhat cheaper if a large lawn is to be fertilized to mix the materials at home. The following mixtures should be satisfactory:

(a) An approximate 10-6-4 fertilizer, with part of the nitrogen in organic form.

Sulfate of ammonia (20% N)	8 pounds

Superphosphate (20% P_2O_5)	5 pounds
Cottonseed meal, activated sludge, or similar material	7 pounds
Muriate of Potash	1 pound

Apply at the same rate as suggested in (1).

(b) An approximate 8-6-6 fertilizer, with part of the nitrogen in organic form.

Sulfate of ammonia (20% N)	6 pounds
Superphosphate (20% P_2O_5)	5 pounds
Cottonseed meal, activated sludge, or similar material	7 pounds
Muriate of potash (60% K_2O)	2 pounds

Apply at the same rate as suggested in (1).

(c) An all organic fertilizer.

One of the best consists of commercial or home dried and pulverized poultry manure. Use at the rate of 45 to 60 pounds per 1000 square feet. Composted poultry manure makes an excellent lawn fertilizer. The organic type of fertilizer is especially desirable for the bluegrass lawn.

(B) For midseason (June) application:

In case the lawn is weedy or but sparsely covered, use sulfate of ammonia or ammonium phosphate (16-20-0) at 3 to 5 pounds per 1000 square feet. It is well to mix ground limestone, pound for pound, with sulfate of ammonia for lawns, when it is not desired to increase their acidity. This may also be used on the mixed bluegrass lawn.

It is essential to spread the fertilizer evenly. It can be more evenly spread when mixed with soil or sand. Fertilize only when the grass is dry unless the job is done during or just before a rain. A blotchy appearance of the lawn is usually the result of an uneven spread of the fertilizer. It is often wise to divide the amount for a given area and spread each part in a different direction.

LIME

The moderate use of lime may increase the usefulness of the fertilizer. Poorer turf has resulted in these experiments where the soil has been allowed to become too acid. Where possible, a test should be made in order to determine the necessity of using lime. A pH of between 5.0 and 6.0 is probably the best range for most conditions. The bents will tolerate a greater degree of acidity than Kentucky bluegrass. If the pH is below 5.0 an application of 50 pounds of limestone per 1000 square feet is suggested as a topdressing. If a new lawn is being established, this amount might well be incorporated with the soil before seeding.

SEEDING

The Experiment Station is often requested to suggest seed mixtures suitable for planting lawns and other areas where a good turf is desired. It is not always possible to say definitely that a certain kind of grass or mixture

is the best for a given condition. Information obtained in these experiments may serve as a guide for making a choice of seed mixtures. Several different mixtures might be suggested for some conditions where it would be difficult to say which one would prove the most suitable. The care used in planting, fertilizing, and after care may have more to do with the success of the venture than the original selection of a certain seeding mixture. Some general suggestions for making a choice of a certain kind of grass or mixture can usually be made. The following are a few suggestions of grasses or mixtures that should prove well suited for the conditions mentioned.

(A) For the average Rhode Island soil that either has not been limed or only to a small extent so that it is still somewhat acid:

(1) For finest quality turf: Rhode Island Colonial bent—seed at the rate of 2 to 3 pounds per 1000 square feet of lawn.

(2) Good quality, less expensive than (1):

Rhode Island Colonial bent	80%
Redtop	20%

Seed 2 to 3 pounds per 1000 square feet.

(3) Good quality and permanent in dry soils and shade:

Rhode Island Colonial bent	30%
Chewing's or Red fescue	50%
Redtop	20%

Seed 4 pounds per 1000 square feet. This makes a tough sod and can be cut short, but is rather hard to mow.

(B) For the moist and relatively fertile soil where lime has been used:

(1)* Good quality turf which stays green both early and late in the season:

Kentucky bluegrass	60%
Rhode Island Colonial bent	20%
Redtop	20%

Seed 3 to 4 pounds per 1000 square feet. This lawn should not be cut closer than 1 inch. If white clover is desired, this may be substituted for part of the redtop and at the rate of one-quarter pound per 1000 square feet.

(2) Good quality turf under shady conditions:

Chewing's or Creeping Red fescue	30%
Rough bluegrass	50%
Ryegrass (perennial)	20%

Seed 4 to 5 pounds per 1000 square feet.

The chances for a good lawn are the best if it is planted in late August or early September. The grass planted in the spring must compete with all of the summer weeds, diseases, and the dry weather as well. Seed on a day soon after a soaking rain, if possible. If it is necessary to seed a lawn

*Canada bluegrass may be substituted for part of the Kentucky bluegrass in this mixture on thin soils.

in the spring of the year, some ryegrass should be added to the mixture. This makes a very quick growth and helps to keep the weeds down until the fine grasses can get started. About 20 per cent of the total weight may consist of perennial ryegrass.

WEED CONTROL

The experiments with different weed control measures indicate that much along this line can be accomplished by proper fertilization and the use of certain chemicals. Where the turf is well fertilized with a high nitrogen fertilizer, the weeds have much less opportunity to become troublesome. Sulfate of ammonia seems to be the most effective source of nitrogen for general weed control.

Arsenate of lead and sodium arsenite were effective in controlling chickweed. The lead arsenate is to be preferred for general use, since it is more readily obtained and is also effective against crabgrass. Applied at the rate of 10 pounds per 1000 square feet of turf it gave very satisfactory control of chickweed and crabgrass.

Maintaining the turf in a very acid condition kept the turf almost entirely weed free but the grasses made poor growth. Maintaining the soil at a moderate acidity proved a much better practice from the standpoint of obtaining a healthy turf growth. Too much liming induced heavy weed infestation.

INSECT AND EARTHWORM CONTROL

Lead arsenate was also found effective in controlling earthworms and webworms in turf. When a lawn is being built a generous application of lead arsenate worked into the soil should prove a good form of insurance against earthworms, white grubs, and the Japanese beetle. At this time it can be used at the rate of 10 pounds per 1000 square feet. Such an application will be effective for several years. On established turf, not previously treated, an annual application of 2 to 5 pounds is suggested for protection. However, if an area is infested with Japanese beetles, apply 10 pounds of arsenate of lead as a control measure.

SUMMARY

The decided change from the natural to the artificial environment for growth is one of the primary reasons for the increasing number of problems in the culture of lawns.

The results reported in this bulletin are based on experiments made at the Rhode Island Agricultural Experiment Station over a period of 40 years.

The plats described have been used to determine the effect of acid, neutral, and basic reacting fertilizers on grass, weeds, and the soil; the amounts of important plant nutrients needed; the preference for different forms of nitrogen; and the behavior of different grasses individually and in mixtures.

The bent grasses are particularly well adapted to the climate and soil of the State and to the growing of fine turf. They are capable of forming continuous turf because of their ability to creep, and are also noted for their tolerance of conditions of acid soil, low fertility, and close clipping. Experiments have shown these grasses to be highly responsive to fertilizing, composting and watering and only moderately responsive to liming.

Rhode Island Colonial bent forms an excellent lawn except in dense shade and in very wet or very drouthy soils. The growth is fine, dense, moderately vigorous, upright, and uniform. A lawn of Colonial bent properly made, fertilized, and cared for will live indefinitely without reseeding.

Two particularly desirable strains of velvet bent are Piper and Kernwood. These have proven excellent for putting greens where necessary care and attention are given. They are not being highly recommended for home lawns unless the owners are willing to topdress, fertilize, and maintain them somewhat similar to putting greens.

The forms of creeping bent such as Seaside, Metropolitan, and Washington are less desirable in Rhode Island than Colonial or velvet bent.

Kentucky bluegrass, in comparison with Colonial bent, grew in cooler weather, stood up under heavier wear but was less able to compete on acid soils and under very close clipping. Bluegrass died out on the acid plats but flourished on the neutral and basic plats. It is recommended in combination with Rhode Island Colonial bent and is particularly desirable for play areas in the back yard, school grounds, and athletic fields if an attempt is made to maintain a soil nearly neutral in reaction and of at least medium fertility.

The fescues survive on soils too dry for bent or bluegrass, tolerate acid soil or dense shade and withstand closer clipping than bluegrass. Chewing's and red fescue are recommended for such purposes.

Domestic or Italian ryegrass is valuable as a nurse grass in mixtures for steep slopes, athletic fields, and where a quick growth is desired to shade and protect the slower growing and more permanent types and to help keep weeds in check.

Suggested mixtures and rates of seeding are given for different types of lawns and for various soil conditions.

In comparing activated sludge with mineral nitrogen in a complete fertilizer for Kentucky bluegrass, the quality ratings show that the organic fertilizer was superior to the mineral, although the turf developed more slowly.

Superphosphate in combination with lime was found to be an excellent preseeding fertilizer.

High amounts of potash stimulated white clover at the expense of the grass. Wood-ashes stimulated clover. Although not primarily a fertilizer, a moderate use of lime, when needed, is suggested in turf culture.

A complete fertilizer high in nitrogen, such as a 10-6-4, 8-6-6, 8-6-4 or a similar analysis, having part of the nitrogen in the organic and part in the inorganic form, is recommended for a general purpose lawn fertilizer.

Topdressing with sterilized compost has improved weedy lawn plats. Proper fertilization improves weedy lawns in a few weeks time. A great many of our common weeds can be eliminated by fertilization.

Arsenate of lead at the rate of 10 pounds per 1000 square feet completely killed chickweed on certain turf plats the first year after treatment.

Sodium arsenite at the rate of 4 ounces in 10 gallons of water injured the turf temporarily but killed mouse-ear chickweed in one month.

Lead arsenate has also proved effective for the control of earthworms and webworms in turf.

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